MAKER: MoDAR

Ms. Fatime Zahra El Fatimi, New York City College of Technology

I am an undergraduate student at the New York City College of Technology. My major is in Computer System Technology. My interest is in computer programming with application in bio-mechatronics and artificial intelligence.

Ms. Felicia Jeter, New York City College Of Technology

I am an undergraduate student at New York City College of Technology. My major is in Computer System Technology with interest in computer programming with applications in bio-mechatronics and artificial intelligence.

Ms. Kayla Leigh Natal

Ms. Natal is an undergraduate student from the New York City College of Technology. Her major is in mechanical engineering technology. Her interest is in mechanical design, mechatronics and computer aided design.

Ehab A. Ahmad,

Mr. Ahmed is an undergraduate student at New York City College of Technology. He is pursuing a degree in mechanical engineering technology. He has technical skills in mechanical design, computer aided design, and product rapid prototyping.

Mr. Ali Harb, New York City College of Technology

Ali Harb Computer Integrated Manufacturing teacher at Brooklyn Technical High School and College Laboratory Technician at New York city College of Technology. I am experienced in robotics, design, and fabrication. I coach and advice students to build Mechatronics devices. Today my interests are in vision, voice recognition, data mining, and gaining more experience in the field of artificial intelligent.

Dr. Andy Zhang, New York City College of Technology

Dr. Andy S. Zhang received his Ph.D. from the City University of New York in 1995. He is currently the program director of a mechatronics project in the New York City College of Technology/CUNY. For the past 15 years, Dr. Zhang has been working on bringing hans-on mechatronics technology to the undergraduate engineering technology curricula and on helping high school students to learn mechatronics through FIRST Robotic Competition (FRC), First Tech Challenge (FTC), and other STEM events.

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Title: Maker: MODAR

Abstract:

MoDAR is a custom-made low cost Mobility Detection and Auto Recognition (MoDAR) smart device that can be used to help physically and visually impaired people to live relatively independently. It utilizes the open-source facial recognition, voice recognition software, and biosensor technology to detect people in its surroundings. This bio-mechatronics device can be a fully automated stand alone system with add on abilities such as global positioning and area mapping to deliver feedbacks to the user. MoDAR can receive commands from the user through voice commands and through a couple of control switches. In addition, the device will be equipped with safety features to warn the user of any potential hazardous situation.

Introduction

Modern product design practices require engineering college graduates to possess multidisciplinary knowledge in many engineering fields, be able to use concurrent engineering approach, and be able to work effectively in teams. As most products nowadays are mechatronics in nature that requires the tight integration of mechanical design with electronics design, and software design to make the product function as desired. MODAR is a student design project that provides opportunities for ordinary undergraduate students to engage in multidisciplinary researches that help students to gain and to accumulate important hands-on experiences and at the same time create product prototypes for potential uses and applications in the biomedical and bioengineering fields which we now call: bio-mechatronics. MoDAR project enables the students to learn the fundamentals of Artificial Intelligent (AI) which represents the new frontier of the technology advancement.

According to the American Community Survey (ACS) conducted by Cornell University's Employment and Disability Institute (EDI) in 2014, blindness among adults for non-institutionalized blind persons aged 16 through 75, is 7,358,400[1]. The number is even higher based on the information gathered from the National Center for Health Statistics in its National Health Interview Survey (NHIS) conducted in 2014 for people ages 18 to 64. It reaches 16.4 million[2]. These people need help in their daily life to deal with hardships related to their blindness.

Currently, there are no reliable statistics on the use of canes or guide dogs in the United States. However, Guiding Eyes for the Blind[3] estimates that "there are approximately 10,000 guide dog teams currently working in the United States. Another frequently cited statistic is that only about 2 percent of all people who are blind and visually impaired work with guide dogs."

MoDAR can serve as a robot guide dog for blind people to help them gain independence and "see" their surroundings in much more friendly manner. MoDAR can retrieve visual and sound information for the blind people and uses GPS to guide its path. As a result, this allows blind people to go to places such as the supermarket, library, or medical offices by themselves. The GPS system would allow users to know where they were at all times. The sensors mounted on

MoDAR allows blind people be able to “read” signs and labels, detect and recognize faces and voices with distinct sounds.

Just like many mechatronic product design, the design of MoDAR involves the mechanical design, electronics/electrical design, and software design.

Mechanical Design Consideration

The physical shape or form of MoDAR can be different depending on the application and on to whom the end user will be. In general we want this stand alone smart device to be light in weight, robust, easy to maneuver, and be able to overcome obstacles.

Original design of MoDAR was based on a humanoid robot called the TOBiAS[4] shown in Figure 1 that a group of students developed at the college a few years ago based on an open-source InMoov model. Since one of MoDAR main focus is on facial recognition, a new head was made using 3D printer to allow two cameras be mounted to the head which serve as eyes for MoDAR. Two arms in the original model were too heavy. As a result the servos that were used were all broken due to heavy mechanical loads they carried. Two new lighter arms using lighter aluminum tubes were used. The modified version with a new head[5] is shown in Figure 2.

Figure 1 TOBiAS Model

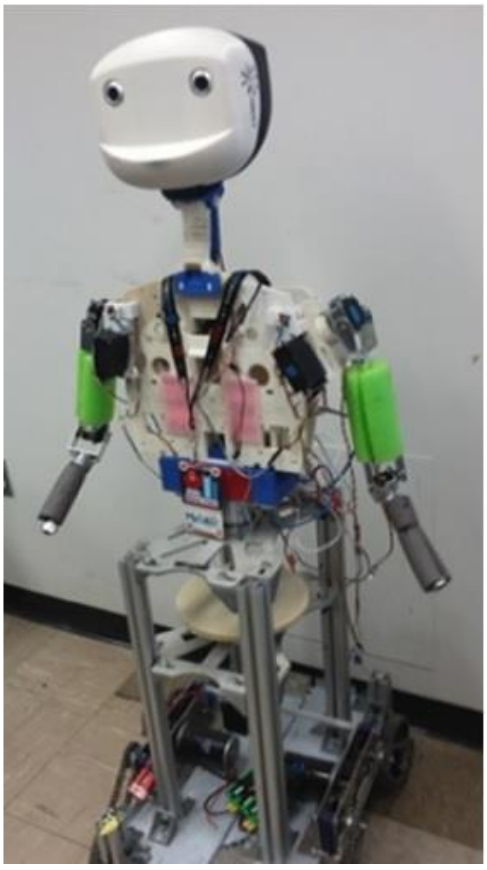


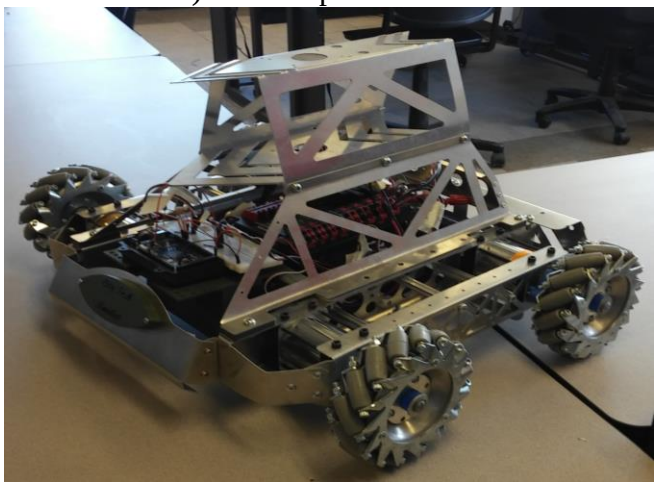
Figure 2 First MoDAR Model

The 6-inch wheel chain drive chassis system in the original model as shown in Figure 3 requires large turning radius which makes it inconvenient to use in tight spaces. At the Maker Session of

this year's ASEE Annual Conference, the audiences will see a new chassis design with four 6-inch Mecanum wheels as shown in Figure 4. The new design was based on a model from Andymark[5]. When equipped with the Mecanum wheels, MoDAR can turn easily.

Figure 3. Old Chassis Design with Chain Drive

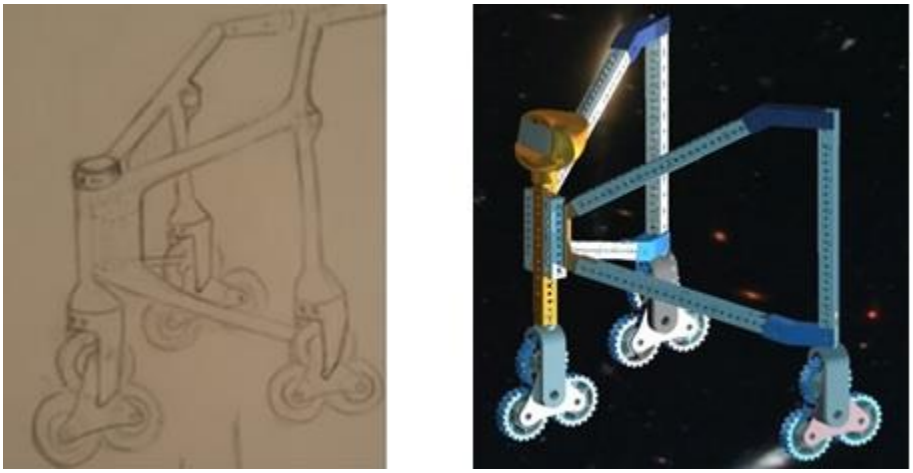
a) A Computer Model



b) A Physical Prototype

Figure 4 New Chassis Design with Mecanum Wheels

If some blind people or those visually impaired prefer using a walker, MoDAR's facial recognition and voice recognition components can be mounted on the walker. A new walker which can be foldable to save space when not in use was conceived and it will be fabricated and tested later. It is designed be able to roll freely on uneven road such as climbing on one or two-inch curbs, and can be driven by actuators if the user desires. The design is based on the tri-wheel system which can help the user to roll over obstacles easily to prevent the user from tripping over. Figure 5 shows a conceptual design and a computer model of the tri-wheel walker system. Each tri-wheel contains three 4-inch wheels that will enable the walker to roll over curbs easily. When the front wheel meets the curb or an obstacle, the upper wheel will roll over to the top of the curb effectively climbing over the curb or obstacle.



a) A conception sketch b) A computer model

Figure 5. Tri-wheel Walker System

Facial Recognition and Voice Recognition Features

MoDAR project's facial and voice recognition features introduce the undergraduate students to the world of Artificial Intelligent (AI). Artificial intelligent is a cutting-edge field that has potential to change the way we live. It provides resources that allow the machines, or robots, or computers to behave and think intelligently like humans. Python and OpenCV were used to program MoDAR.

Artificial intelligence is progressing at an accelerated pace in recent years. Most people perceive AI as creating human-like robots or humanoids, it is more than that. AI is to use neural network theories to simulate the human thinking processes by computers; to inject the human's ability to screening data, provide sound reasoning, to make self-reflection, and self-correction decisions to the computers. According to TechTarget, artificial intelligence can be broken down into two main categories: Weak AI (or called Machine Learning category), which is a machine's ability to be trained to perform specific tasks. Strong AI (or Deep Learning category) is the machine's ability when equipped with enough cognitive skills, to find solutions to problems on their own. Particular applications of AI include expert systems, speech recognition and machine vision[7].

The two learning processes can be described and explained by the following figure[8].

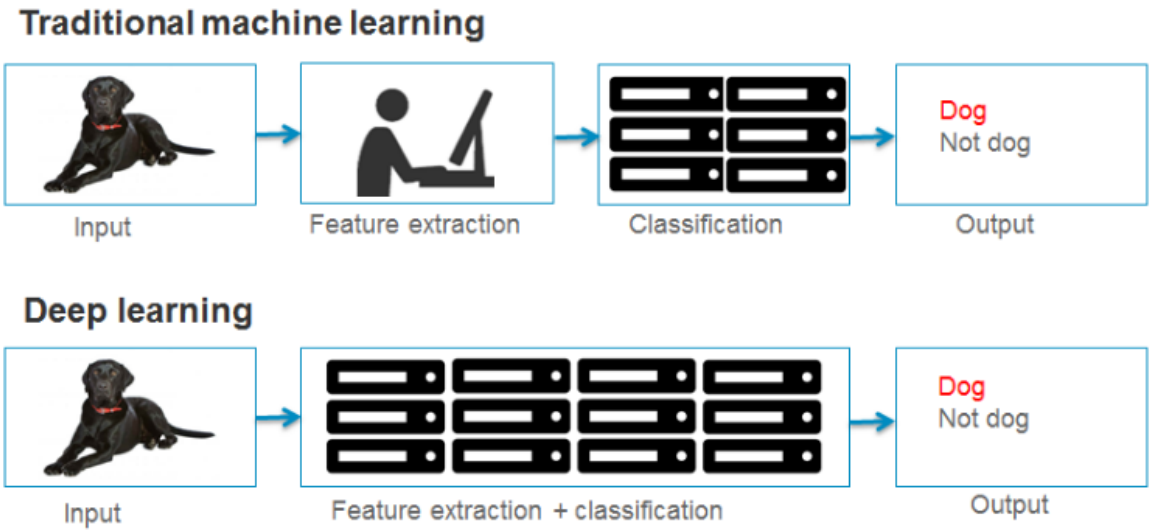


Figure 6 Machine Learning vs. Deep Learning[8]

The initial phase of the MoDAR project is to allow students who are working on facial and voice recognitions to practice using machine learning algorithms to accumulate programming skills and experiences and learn what work and what does not. It takes time for students to accumulate certain knowledge and skills so they can later focus on developing and testing various codes for MoDAR that can recognize changes in facial and sound patterns when exposed to new data. MoDAR's facial recognition ability resembles computer's data mining procedures. They both sieve through what seemed to be unrelated data set and look for patterns. MoDAR uses that data to detect certain characteristics of facial patterns in the data set and adjust its behavior accordingly. In order to accomplish these tasks, students did extensive results on topics of artificial intelligence [9-16].

When MoDAR is completely finished which we expect would take at least another year, it will have many useful features such as the ones shown in Figure 7. Since we are new to the field of artificial intelligent, for the moment, we have only worked and experimented with optical character recognition (OCR), voice recognition and facial detection and recognition.

MoDAR's various features are explained below. We expect to develop solutions for all the features in one more year which require extensive programming and use of systems with faster CPU or GPU.

WhaDat – is an application for object recognition. It allows the users to be able to detect objects in their surroundings.

WhoDat – is an application for face recognition, the user will get a feedback from MoDAR for recognizing the people he or she already knew people, if these facial feature are being saved in the MoDAR database. If the user encounters new people, the user will be informed and he has an ability to add the new people into MoDAR's database.

WhereAmI - is an application to determine location and surroundings by utilizing Laser Light Detection and Ranging technology .

Read2Me – is an application that recognizes signage by extracting text from images. It uses OCR (optical character recognition) technology

MoDAR…- is an application for a voice controlled "assistant "

SamSays – is an application for voice recognition, the user will get a feedback from MoDAR recognizing speakers' voice if their voice is saved in the database.

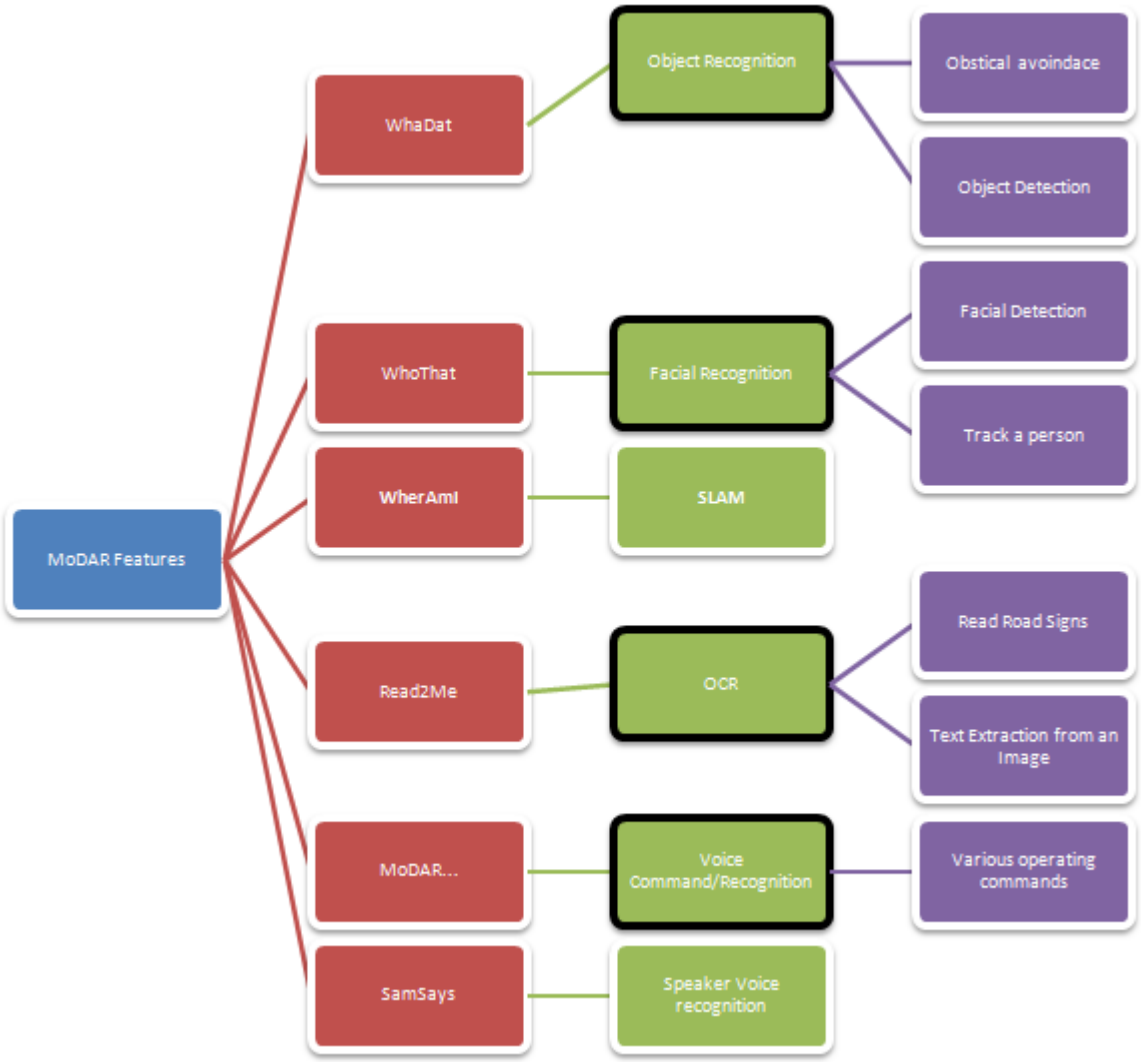


Figure 7. MoDAR's Features

Preliminary Results

Extensive amount of time were spent on learning Python, OpenCV, Arduino microcontroller, Raspberry Pi, and many other electronic components, actuators, and sensor.

Three months after we started the MoDAR project last summer, MoDAR was able to say greetings to people and detect faces. In order to recognize the faces it saw, we need to create a database to store these images first. We are working on it.

MoDAR can also recognize words. But they have to be placed in a box because ambient light affect MoDAR's ability to read them correctly.

MoDAR can recognize certain voice commands and move its arms based on the voice commands. In order to remove the effect of noise or sound in the surroundings that affect the precisions that the MoDAR receive the voice commands, we need to explore different types of speaker devices, ear phone, and filtering codes.

Early models of MoDAR prototypes have been tested in various occasions such as in 2016 New York Maker Faire, in 2016 Google Street Geek Fair held in Union Square Park in New York, and in 2016 NYU Mechatronic Workshop. Figure 7 shows MoDAR greeting an audience during the 2016 NYU Mechatronic Workshop demonstration held in Brooklyn, New York.

Figure 7. MoDAR at the 2016 NYU Mechatronics Workshop

Future Work

Once the students master the fundamental knowledge of Machine Learning, they will work on making MoDAR to be able to acquire Deep Learning skills which can emulate the learning

behavior that humans use to gain certain types of knowledge. At its simplest, with the implementation of deep learning algorithms to MoDAR, it will make MoDAR's behavior more predictive.

Programming with traditional machine learning algorithms are relatively easier because all the problems are linearly defined. Programming with deep learning algorithms are more challenging because they are non-linear and the data are stacked in various hierarchy levels with increasing complexity and abstraction. Each algorithm in the hierarchy need to use a non-linear transformation technique to treat its input and applies what it learns to create a statistical model as output. This type of iterations continues until the output converges and has reached an acceptable level of accuracy. The number of processing layers through which data must pass is what inspired the word "deep" learning[17].

To use deep learning algorithms, we need to learn special theories and techniques such as Convolutional neural network (CNN), artificial neural network (ANN), forward propagation technique, Bounding Box Algorithms, and backward propagation method.

This presents a challenge and an opportunity for us in order to make MoDAR functions the way we originally anticipated.

Acknowledgements

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